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NASA

MEMORANDUM

for the

U. S. Air Force

AN INVESTIGATION OF THE STATIC LONGITUDINAL, LATERAL, AND DIRECTIONAL STABILITY CHARACTERISTICS OF A 1/10-SCALE MODEL OF THE CONVAIR TCP BOMB

COORD. NO. AF-AM-145

By James C. Patterson, Jr.

Langley Research Center
Langley Field, Va.

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AN INVESTIGATION OF THE STATIC LONGITUDINAL, LATERAL, AND DIRECTIONAL STABILITY CHARACTERISTICS OF A 1/10-SCALE MODEL OF THE CONVAIR TCP BOMB*

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ABSTRACT

This investigation indicates that the bomb (body-fin configuration) was stable both longitudinally and directionally and had neutral effective dihedral except at large negative angles of attack. The addition of the pylon caused a shift in trim angle of -4° at most Mach numbers as well as causing the bomb to have negative effective dihedral at all positive and small negative angles of attack. This addition of the pylon had little or no effect on the directional stability characteristics of the bomb.

INDEX HEADINGS

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Tail-Body Combinations - Missiles	1.7.2.1.2
Stability, Static	1.8.1.1

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AN INVESTIGATION OF THE STATIC LONGITUDINAL, LATERAL, AND DIRECTIONAL STABILITY CHARACTERISTICS OF A 1/10-SCALE MODEL OF THE CONVAIR TCP BOMB*

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SUMMARY

The static longitudinal, lateral, and directional stability characteristics of a 1/10-scale model of the Convair TCP bomb have been investigated in the Langley 8-foot transonic tunnel. During this investigation the Mach number ranged from 0.80 to 1.2 over an angle-of-attack range of -12° to 6° at various sideslip-angle settings of 0°, $\pm 2^{\circ}$, and 5°. The contribution of the fins and pylon to the static stability of the bomb has been determined over an average Reynolds number range of 12.71×10^{6} to 13.53×10^{6} based on body length.

The results of this investigation indicate that the bomb (body-fin configuration) is stable longitudinally and directionally throughout the transonic speed range. The addition of the pylon to the bomb configuration caused a -4° shift in trim angle at most Mach numbers, as well as causing the effective dihedral to become negative at all positive and at small negative angles of attack. This addition of the pylon caused little or no change in the directional stability characteristics of the bomb.

*Title, [redacted]

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INTRODUCTION

An investigation of the static stability characteristics of a 1/10-scale model of the Convair Two Component Pod (TCP) bomb at transonic speeds has been made at the request of the U. S. Air Force.

The contributions of the fins and pylon to the static longitudinal, lateral, and directional stability of the bomb were investigated in the Langley 8-foot tunnel over a Mach number range of 0.80 to 1.2, through an angle-of-attack range of -12° to 6° at sideslip settings of 0°, $\pm 2^\circ$, and 5°. The average Reynolds number, based on body length, varied from 12.71×10^6 to 13.53×10^6.

SYMBOLS

All force and moment coefficients were reduced about the body axis having the sign convention shown in figure 1. The moment reference center was located at the 17.46 body station.

C_N normal-force coefficient, $\frac{\text{Normal force}}{qA_B}$

C_A axial-force coefficient, $\frac{\text{Axial force}}{qA_B}$

C_m pitching-moment coefficient, $\frac{\text{Pitching moment}}{qA_Bd}$

C_l rolling-moment coefficient, $\frac{\text{Rolling moment}}{qA_Bd}$

C_n yawing-moment coefficient, $\frac{\text{Yawing moment}}{qA_Bd}$

C_Y side-force coefficient, $\frac{\text{Side force}}{qA_B}$

$C_{A_{\alpha=0^\circ}}$ axial-force coefficient at zero angle of attack

A_B maximum cross-sectional area, 0.07568 ft^2

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d	maximum cross-sectional diameter, 0.31042 ft
q	free-stream dynamic pressure
M	free-stream Mach number
R	Reynolds number
α	angle of attack, deg
β	angle of sideslip, deg

$C_{n_\beta} = \frac{\partial C_n}{\partial \beta}$ per deg

$C_{l_\beta} = \frac{\partial C_l}{\partial \beta}$ per deg

i_t	fin incidence, deg

APPARATUS

Tunnel

The Langley 8-foot transonic tunnel has a longitudinally slotted test section to permit continuous operation throughout the transonic speed range up to a Mach number of 1.2 without choking. Complete details of the Langley 8-foot transonic tunnel are presented in reference 1.

Model

The model used in this investigation consisted of a body of revolution having a fineness ratio of 10.92, a pylon used to attach the bomb to the aircraft, and three fins set at 120° apart with the lower fin vertical as shown in figures 2 and 3. The two upper fins will be referred to as the horizontal fins throughout this report.

Tests and Measurements

Tests were made in the Langley 8-foot transonic tunnel through a Mach number range of 0.80 to 1.2 on the basic body; body and pylon; body and fins $\left(i_t = 0^\circ\right)$; and body, horizontal fins $\left(i_t = 0^\circ, 2^\circ\right)$, and pylon. These configurations were tested over an angle-of-attack range of -12° to 6° and at various sideslip settings of $\beta = 0^{\circ}$, $\pm 2^{\circ}$, and 5°. A test was also made with the body-pylon-fin $\left(i_t = 0^{\circ}\right)$ configuration rotated 90° with respect to the horizontal and at an angle of attack of -5° while the angle of sideslip was varied from -12° to 6°. Transition was fixed during the entire investigation by applying No. 100 carborundum grain to the forward 10 percent of the bomb body.

A six-component strain-gage balance, internally mounted and attached to a sting support system, was used to measure the forces and moments experienced by the model. The angle of attack was measured by an electrical strain-gage pendulum device located just ahead of the balance. The base pressure was measured by a static-pressure orifice just inside the base of the model and was used to correct the pressure at the base of the model to that of the free-stream static pressure.

The variation of the average Reynolds number with Mach number is shown in figure 4.

Accuracy

The following estimated accuracy of the coefficients, based on balance accuracy and repeatability of the data, is estimated as:

C_N	± 0.014
C_A	± 0.0043
C_m	± 0.024
C_l	± 0.0010
C_n	± 0.013
C_Y	± 0.0054

RESULTS AND DISCUSSION

Basic Aerodynamic Data

The basic data of normal-force, axial-force, side-force, pitching-moment, rolling-moment, and yawing-moment coefficients plotted against angle of attack at $\beta = 0^{\circ}$, $\pm 2^{\circ}$, and 5° are presented in figure 5. Figure 6 presents the variation of the basic data with angle of sideslip β at an angle of attack of -5°.

Longitudinal Stability

The body-alone configuration was unstable throughout the Mach number and angle-of-attack range shown in figure 5(a). The addition of the pylon to the body alone caused little or no change in the longitudinal stability characteristics of this configuration.

The body-fin configuration had positive longitudinal stability with a slight decrease in stability at angles of attack near 0° at Mach numbers ranging from 0.80 to 1.03. As the Mach number was increased to 1.2, the curves tended to become more linear.

The data of figure 5(a) show that all configurations except the body-pylon-fin $\left(i_t = 0^\circ\right)$ configuration trimmed at zero angle of attack at each Mach number. The addition of the pylon to the body-fin $\left(i_t = 0^\circ\right)$ configuration resulted in a shift in trim angle from $\alpha = 0^\circ$ to approximately -4° at all Mach numbers except at $M = 1.2$ where this shift was about 1° less. This shift in trim angle experienced by the body-pylon-fin configuration could possibly be attributed to a change in flow angularity over the fins caused by the pylon. This change in flow angularity in effect increased the fin incidence resulting in a negative shift in trim angle. However, by employing a -2° incidence to the horizontal fins, the configuration was made to trim at an angle of attack of 0° at all Mach numbers except at a Mach number of 1.2 where the trim angle was moved to an angle of attack of 1°.

All configurations employing fins were stable at each sideslip setting used during this investigation with pitching moments similar to those at $\beta = 0^\circ$. (See figs. 5(a), (c), (e), and (g).)

Lateral Stability

The body-fin configuration had neutral effective dihedral at all positive and small negative angles of attack at each Mach number shown. (See fig. 7.) As the angle of attack was decreased further this configuration became unstable except at angles of attack below -11° at a Mach number of 0.80 where the body-fin configuration had positive effective dihedral $\left(-C_{l_\beta}\right)$.

The body-pylon configuration had positive effective dihedral throughout the angle-of-attack and Mach number range. The degree of effective dihedral decreased with an increase in angle of attack.

The combination of the pylon and fins caused the bomb to have negative effective dihedral at all positive and small negative angles of attack (-2° or less). The flow interaction between the pylon and the horizontal fins plus the fact that the lower vertical fin was more exposed in these attitudes could possibly cause this loss in stability.

Directional Stability

The body-pylon configuration had negative static directional stability throughout the angle-of-attack and Mach number range except at $\alpha = -10^\circ$ at a Mach number of 0.80. (See fig. 8.)

The body-fin configuration was stable throughout the entire angle-of-attack and Mach number range with a greater degree of stability at positive angles of attack. This increase in stability could possibly be attributed to the lower vertical fin emerging from the wake of the body; thus, more fin area was exposed to the flow, increasing the fin effectiveness at these positive angles of attack.

The addition of the pylon to the body-fin configuration had only a slight effect on the directional stability of the body-fin configuration; this effect added to the stability of the bomb except at negative angles of attack greater than -9°.

Axial Force

The addition of the pylon to the body-fin configuration increased the axial-force coefficient by an increment of approximately 0.02 at Mach numbers ranging from 0.80 to 0.95. (See fig. 9.) Above the drag-rise Mach number ($M = 0.95$) the increase in axial force became greater with a maximum increase of 0.034 at a Mach number of 1.2.

The -2° fin incidence employed had only a slight effect on the axial force.

CONCLUDING REMARKS

The results of this investigation of a 1/10-scale model of the Convair TCP bomb indicate that the bomb (body-fin configuration) is stable longitudinally and directionally throughout the transonic speed range.

The addition of the pylon to the bomb configuration caused a -4° shift in trim angle at most Mach numbers, as well as causing the effective dihedral to become negative at all positive and at small negative angles of attack.

The addition of the pylon to the bomb configuration had little or no effect on the static directional stability characteristics of the bomb.

Langley Research Center,
National Aeronautics and Space Administration,
Langley Field, Va., September 19, 1958.

REFERENCE

1. Ritchie, Virgil S., and Pearson, Albin O.: Calibration of the Slotted Test Section of the Langley 8-Foot Transonic Tunnel and Preliminary Experimental Investigation of Boundary-Reflected Disturbances. NACA RM L51K14, 1952.

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1/10-SCALE MODEL OF THE CONVAIR TCP BOMB

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James C. Patterson, Jr.
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Approved: Eugene C. Draley
Eugene C. Draley
Chief of Full-Scale Research Division
Langley Research Center

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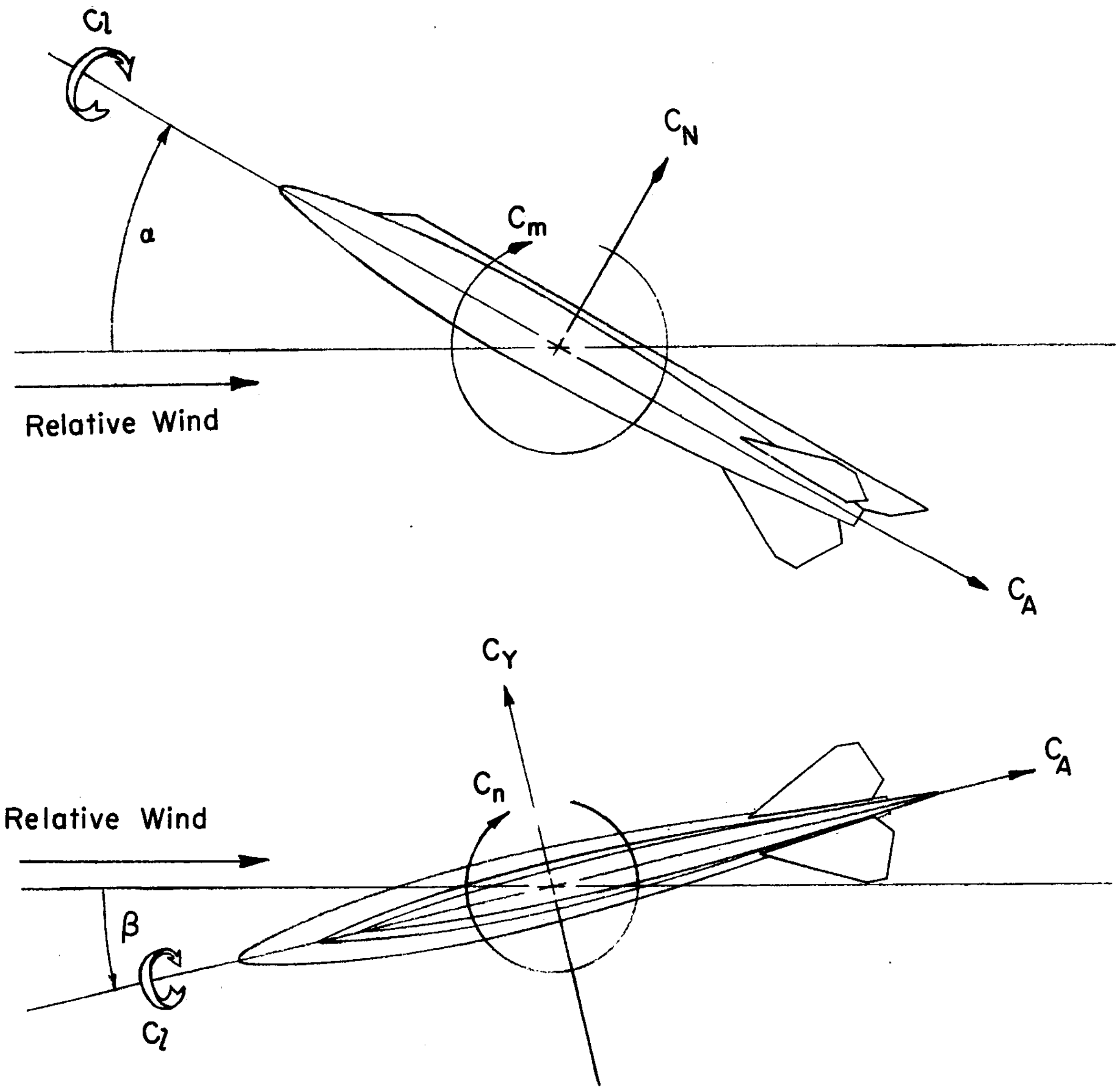

Figure 1.- Force and moment convention.

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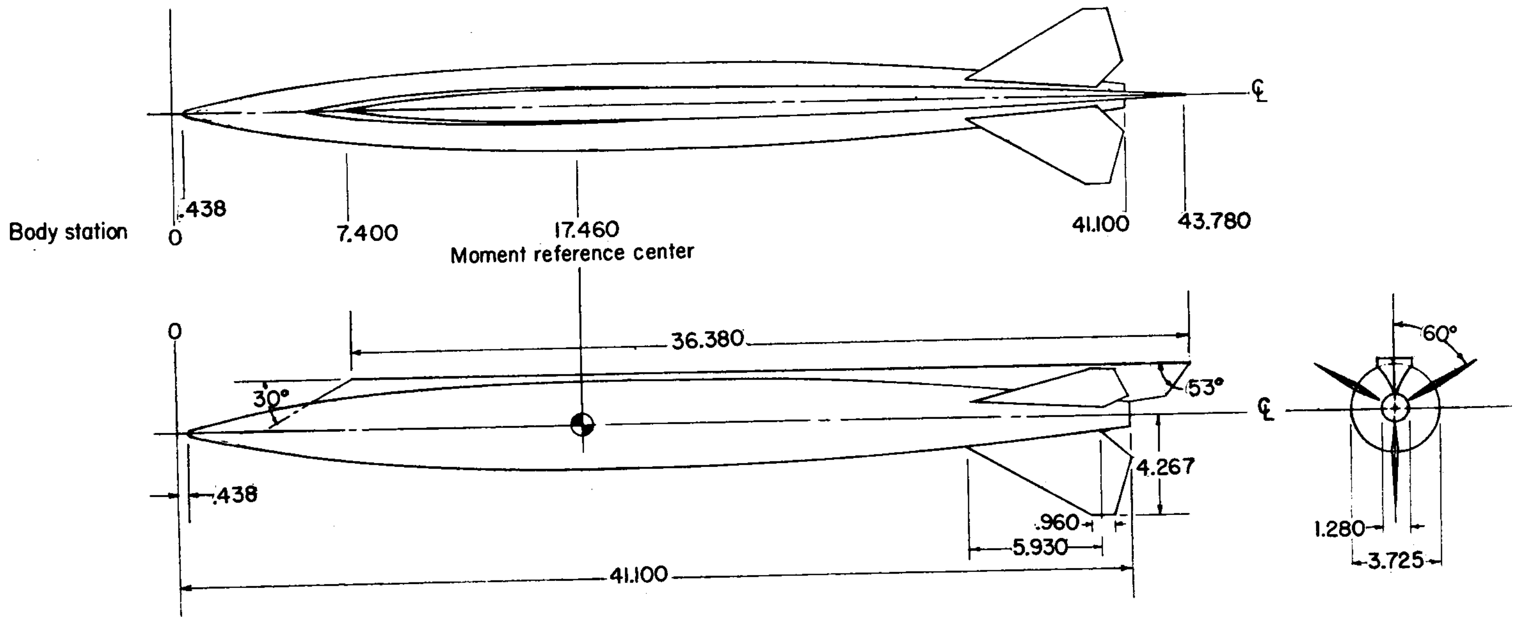

Figure 2.- The complete-model configuration. All dimensions are in inches.

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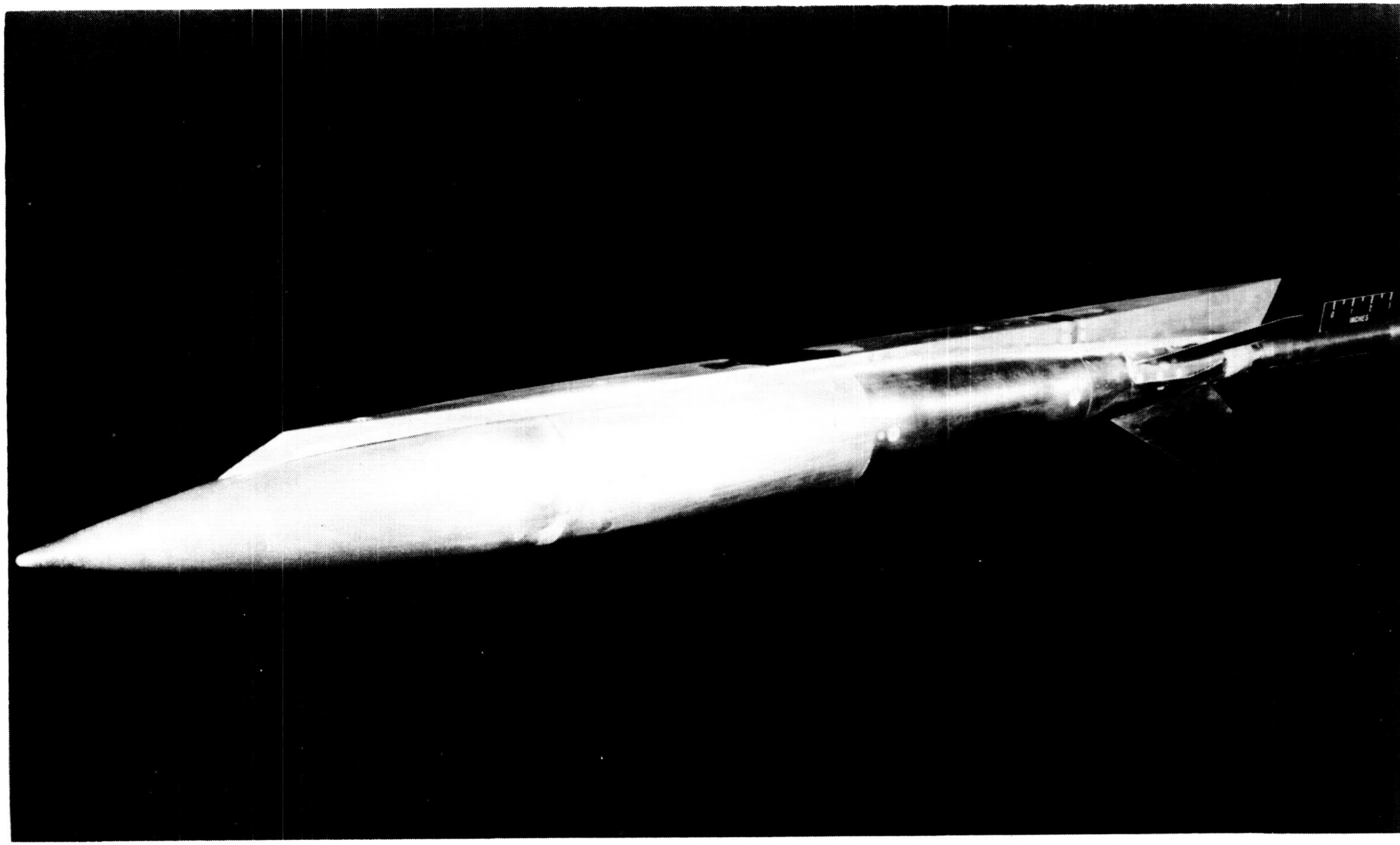

Figure 3.- The complete-model configuration including the body, pylon, and fins. L-57-4948

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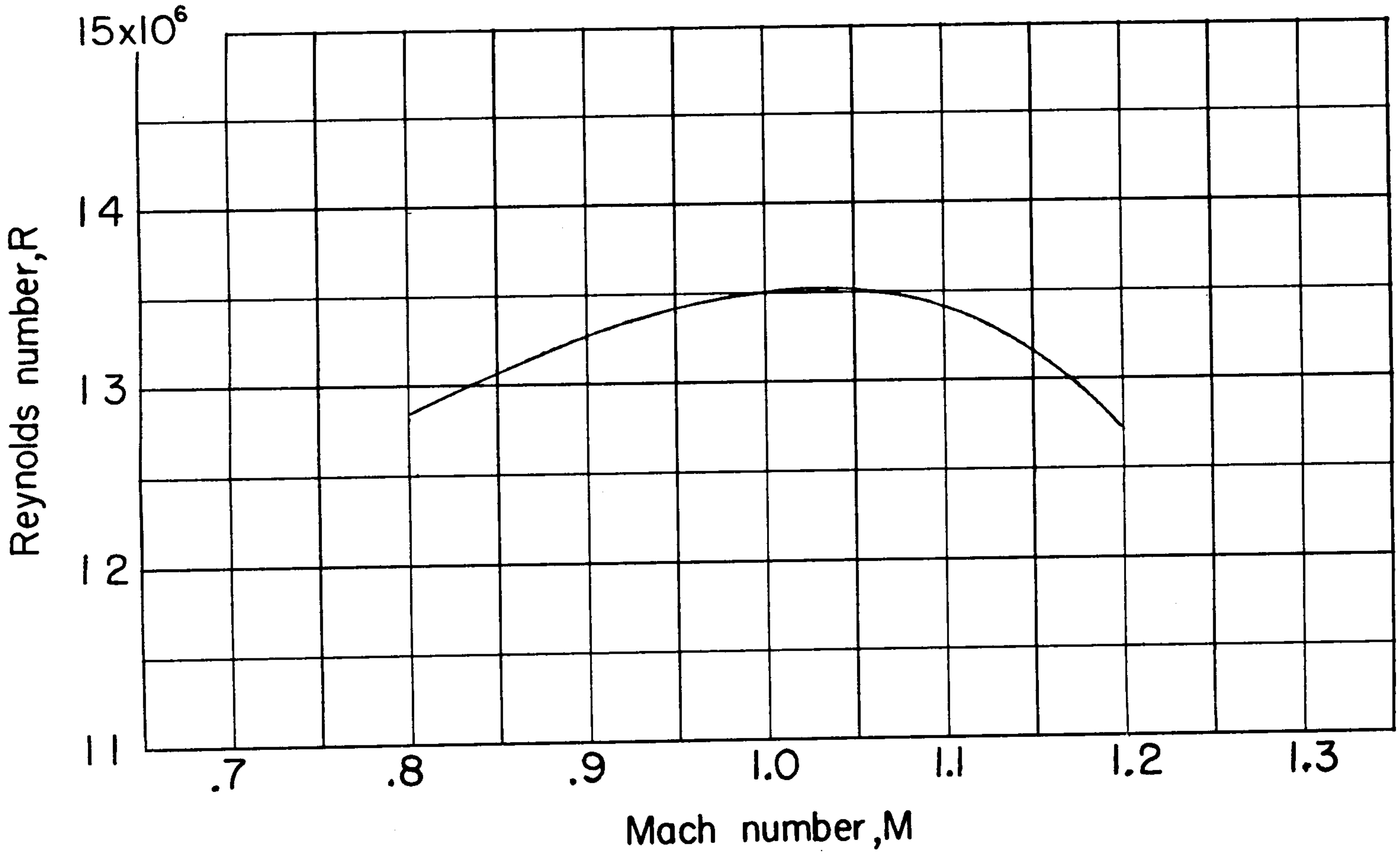

Figure 4.- Variation of Reynolds number, based on body length, with Mach number.

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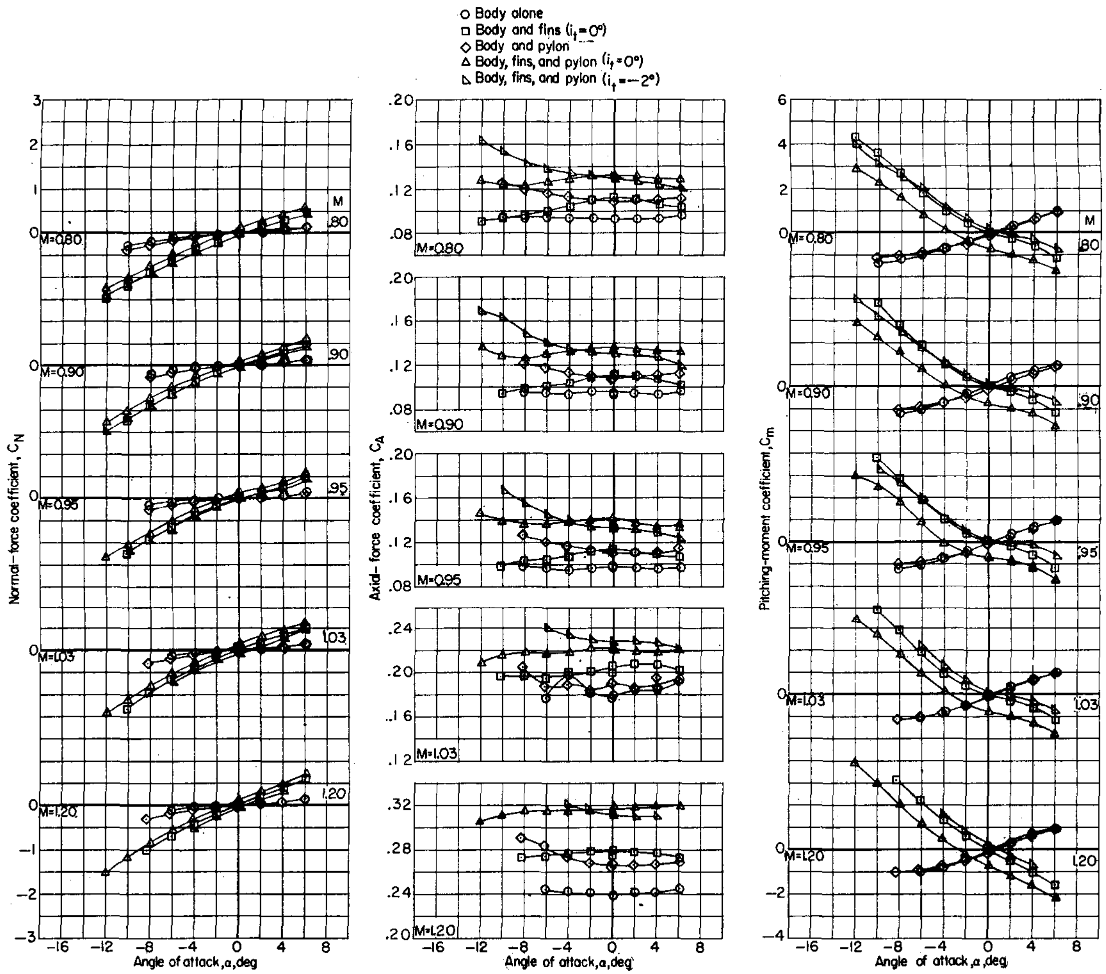

(a) $\beta = 0^{\circ}$.

Figure 5.- Variation with angle of attack of the aerodynamic characteristics of the configurations tested at various Mach numbers.

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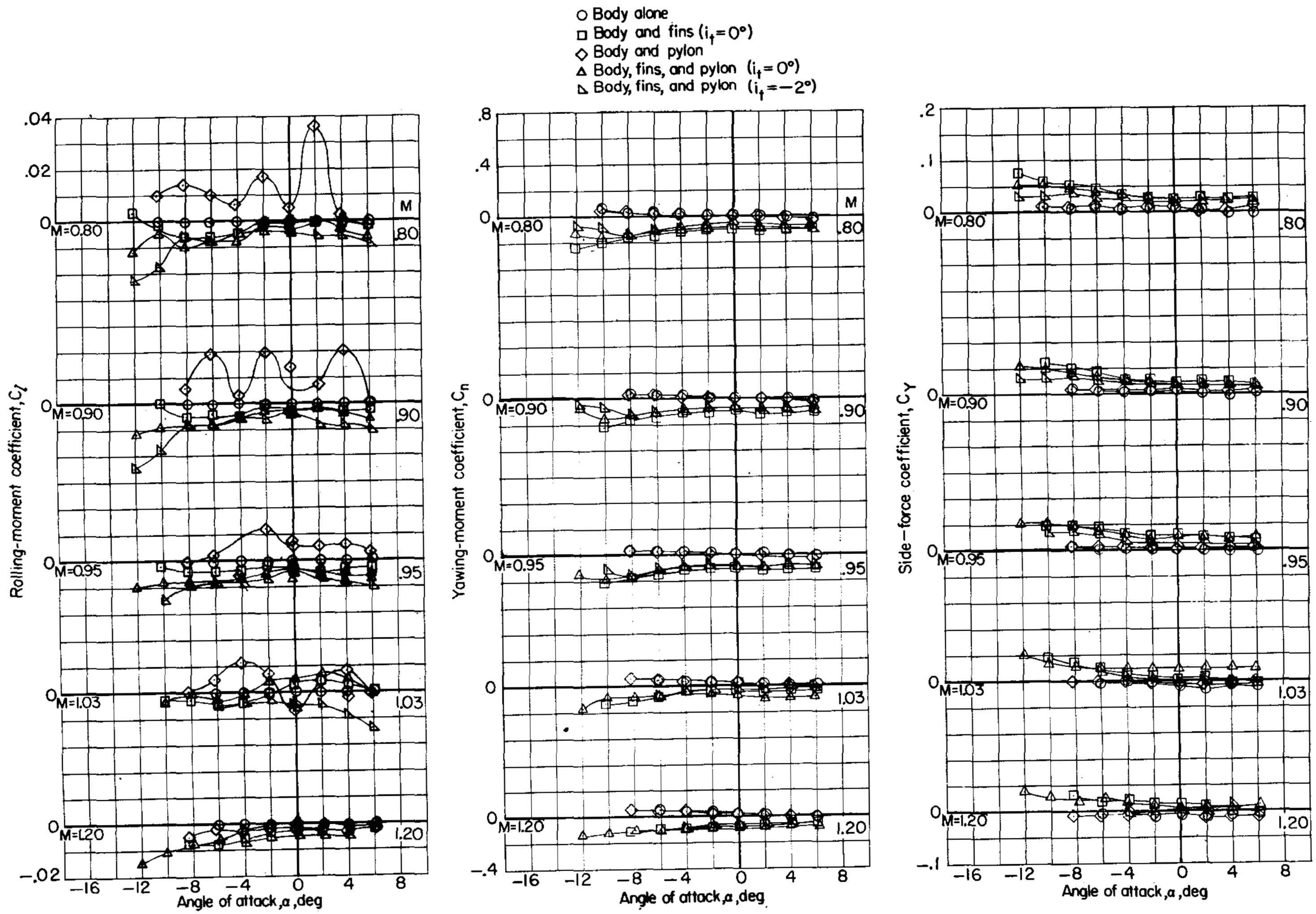

(b) $\beta = 0^{\circ}$.

Figure 5.- Continued.

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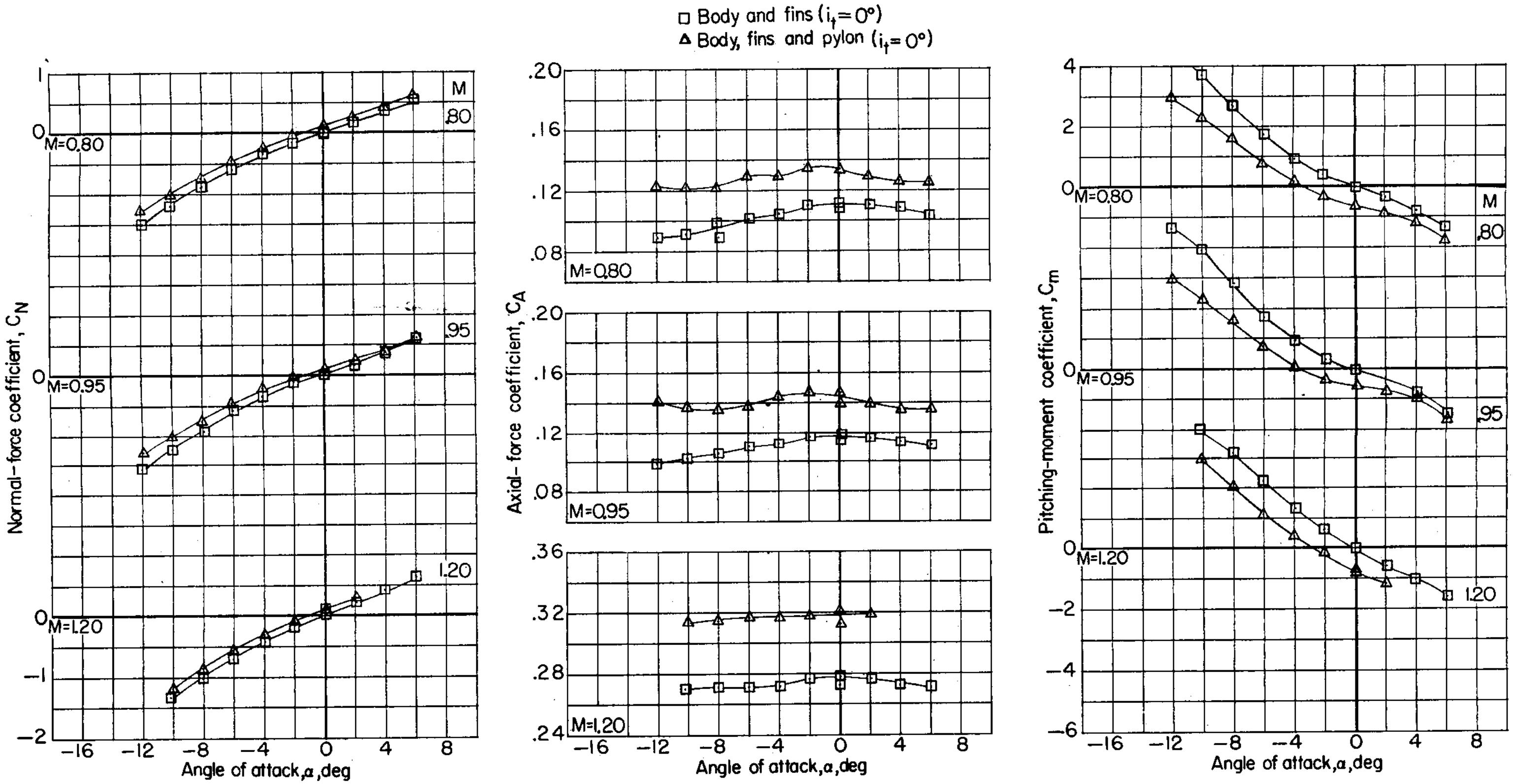

(c) β = -2°.

Figure 5.- Continued.

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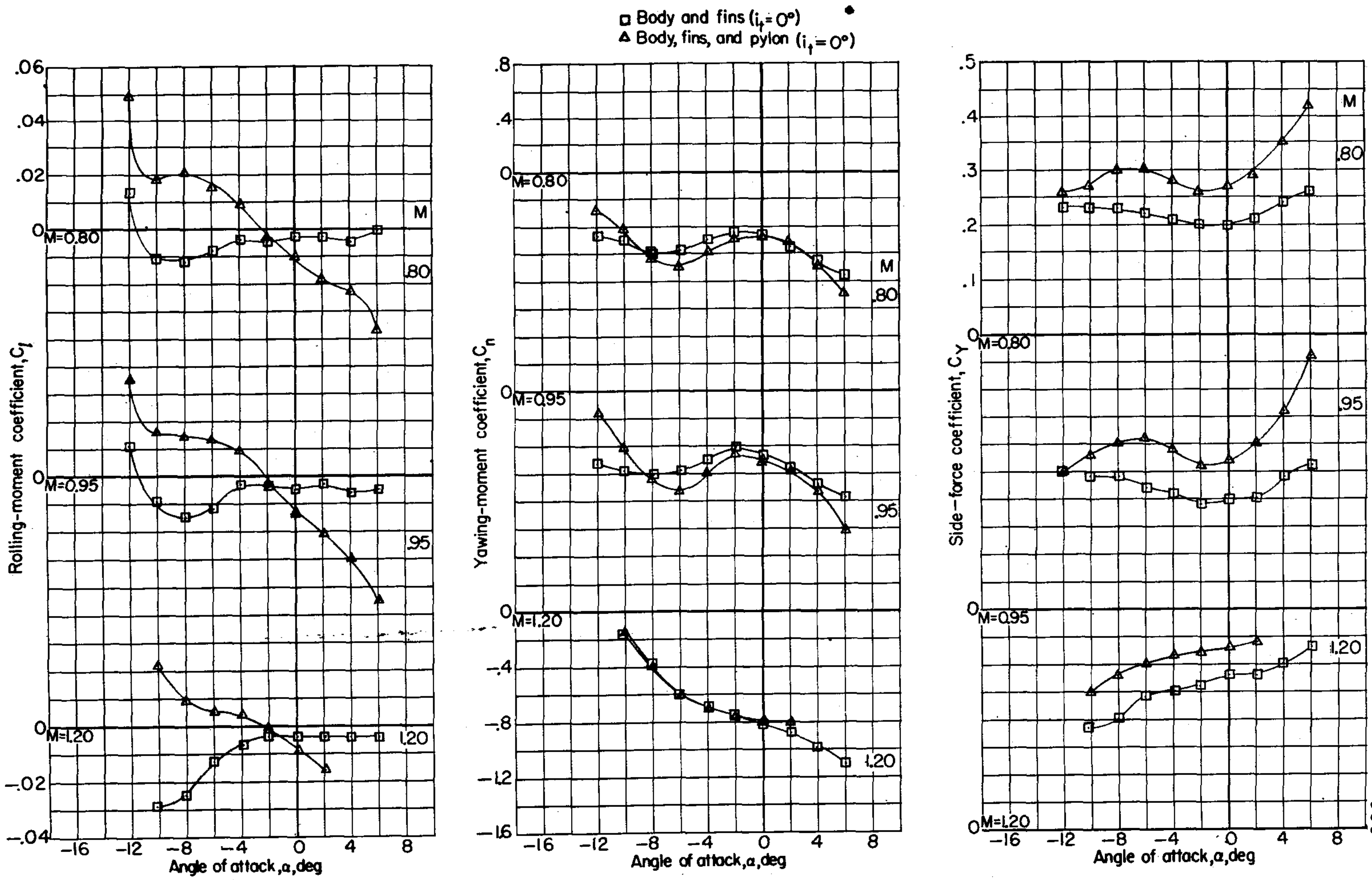

(d) $\beta = -2°$.

Figure 5.- Continued.

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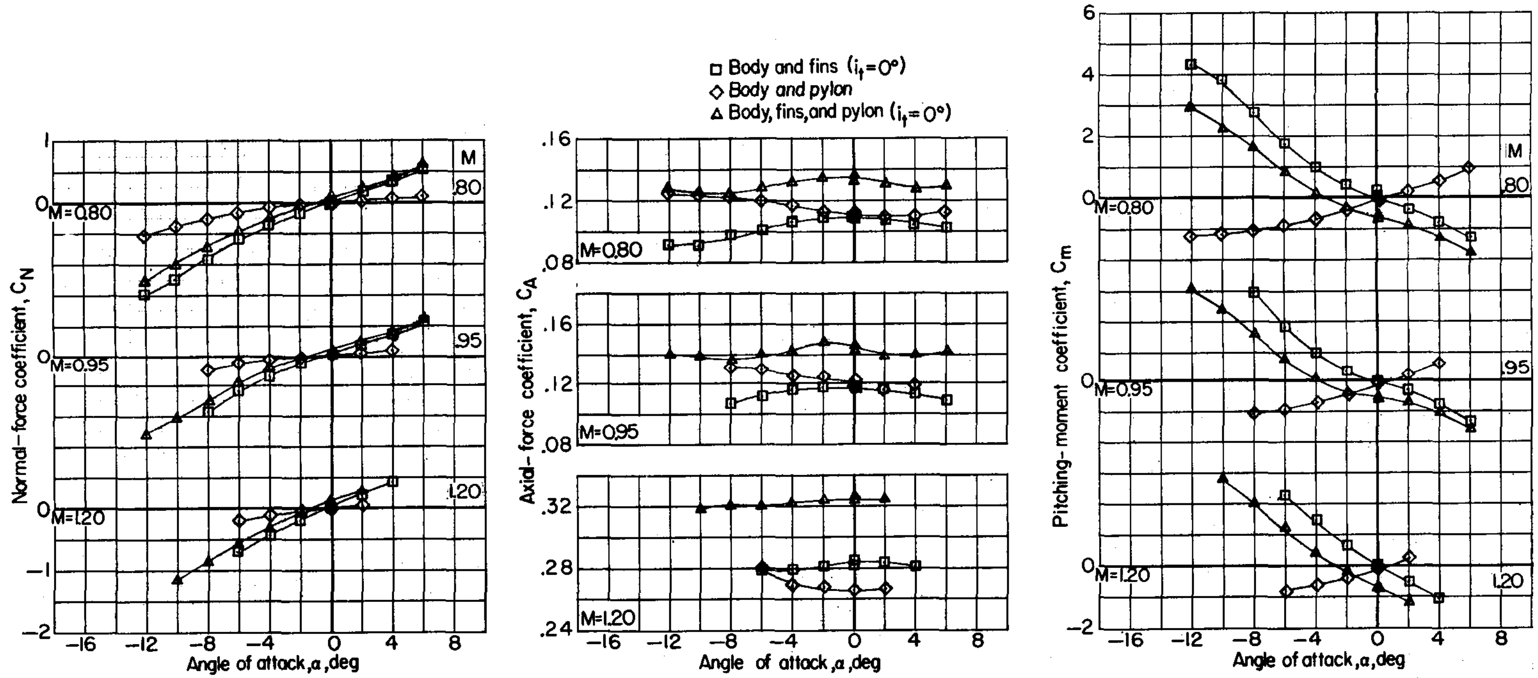

(e) $\beta = 2^{\circ}$.

Figure 5.- Continued.

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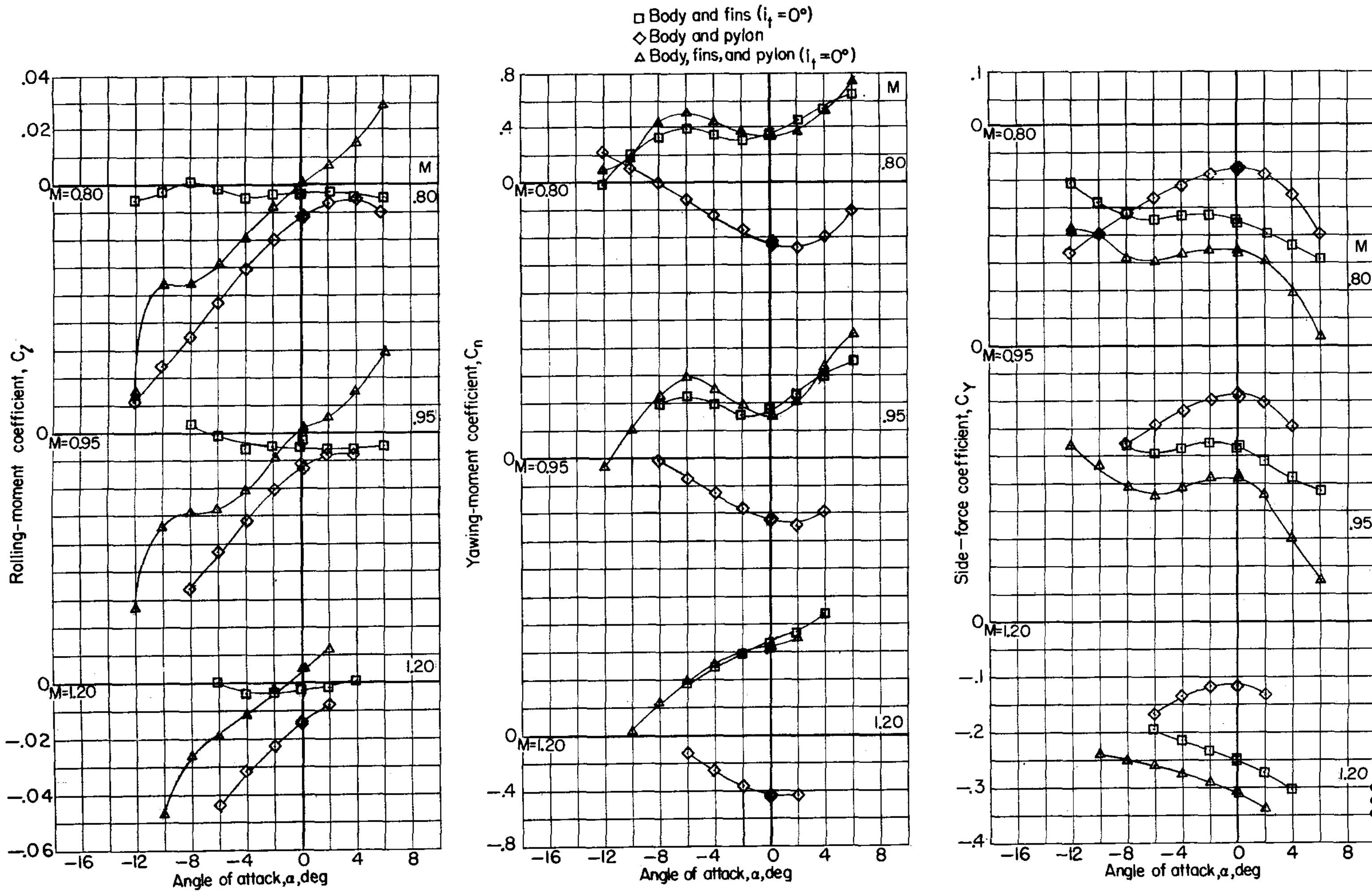

(f) $\beta = 2^{\circ}$.

Figure 5.- Continued.

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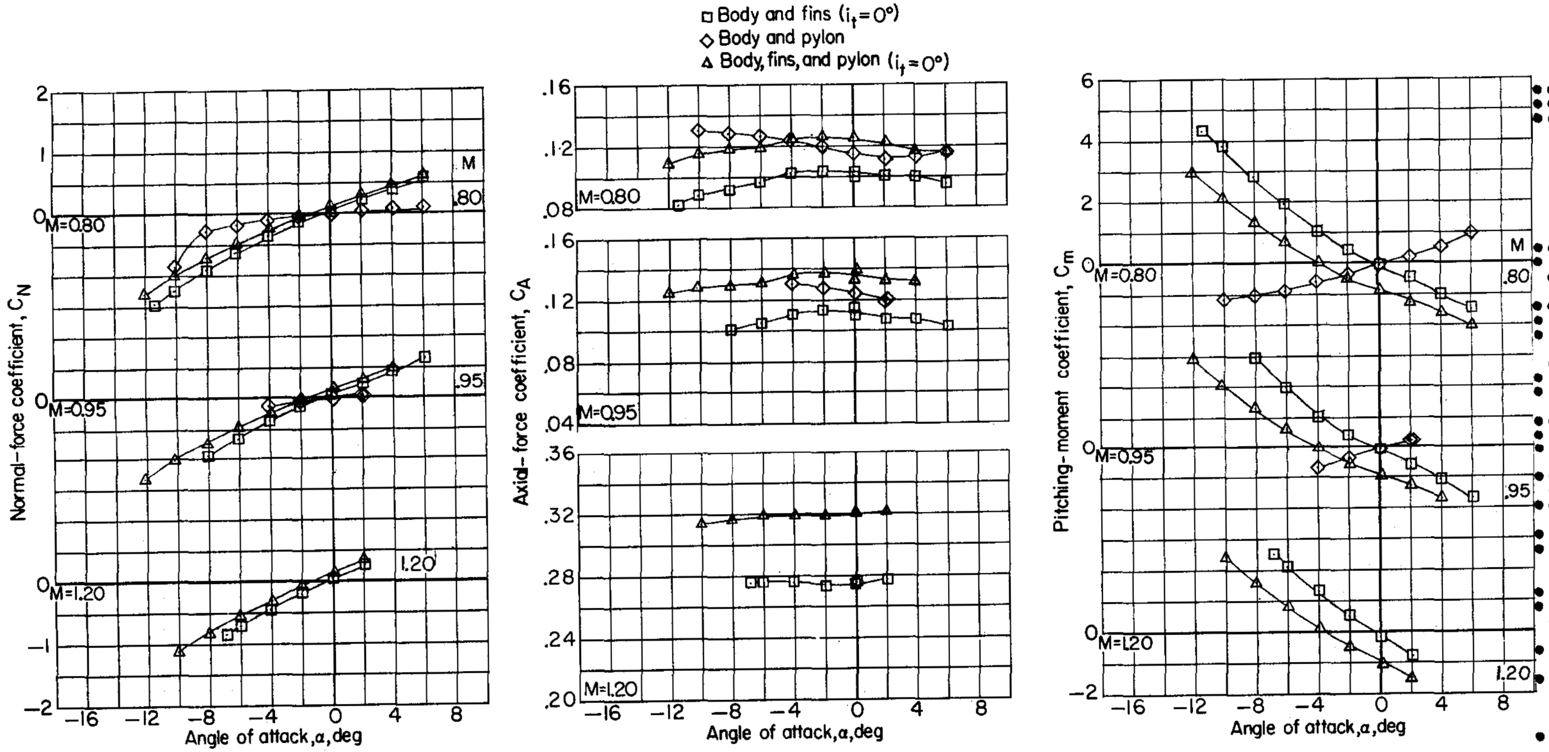

(g) β = 5°.

Figure 5.- Continued.

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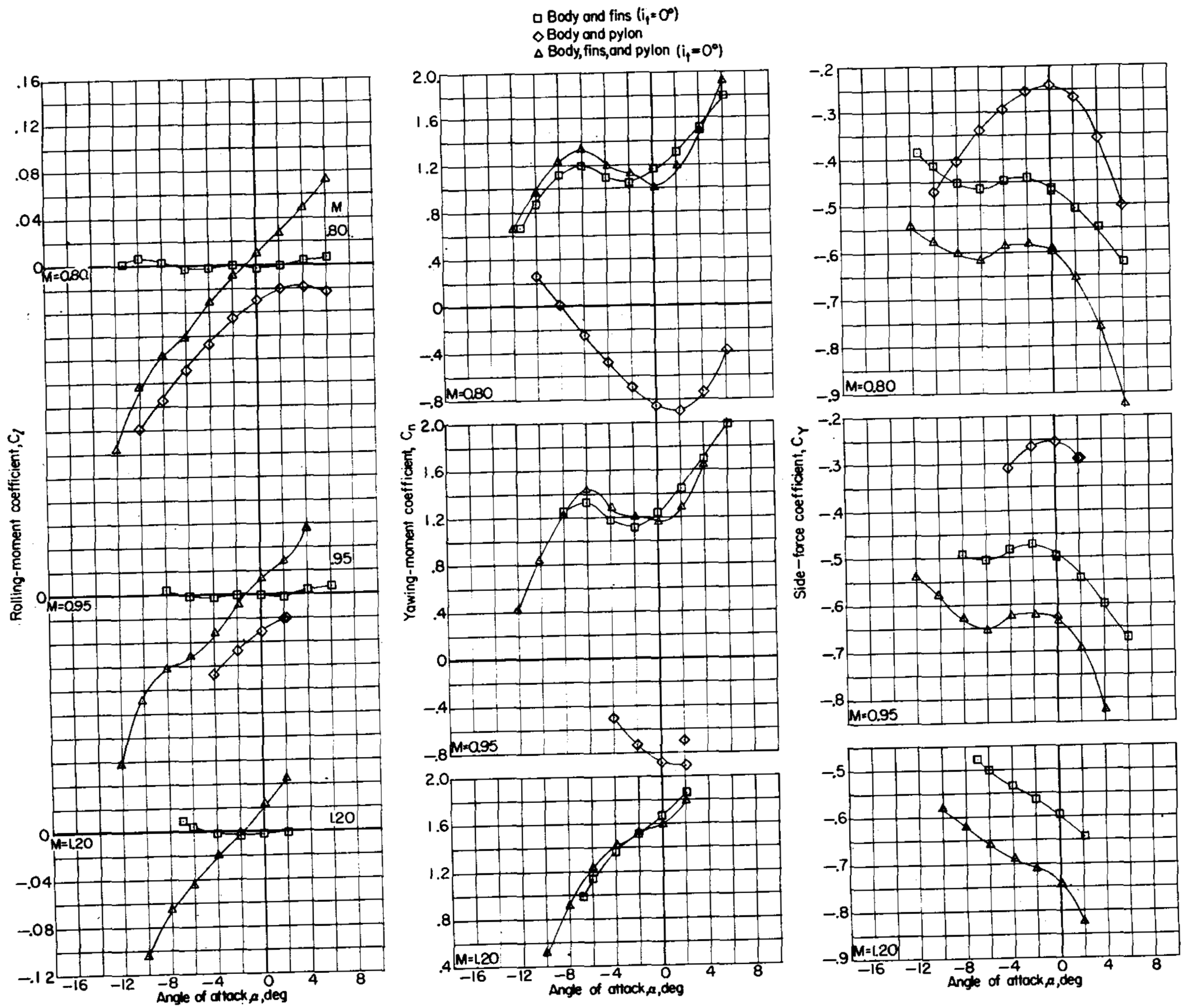

(h) $\beta = 5^{\circ}$.

Figure 5.- Concluded.

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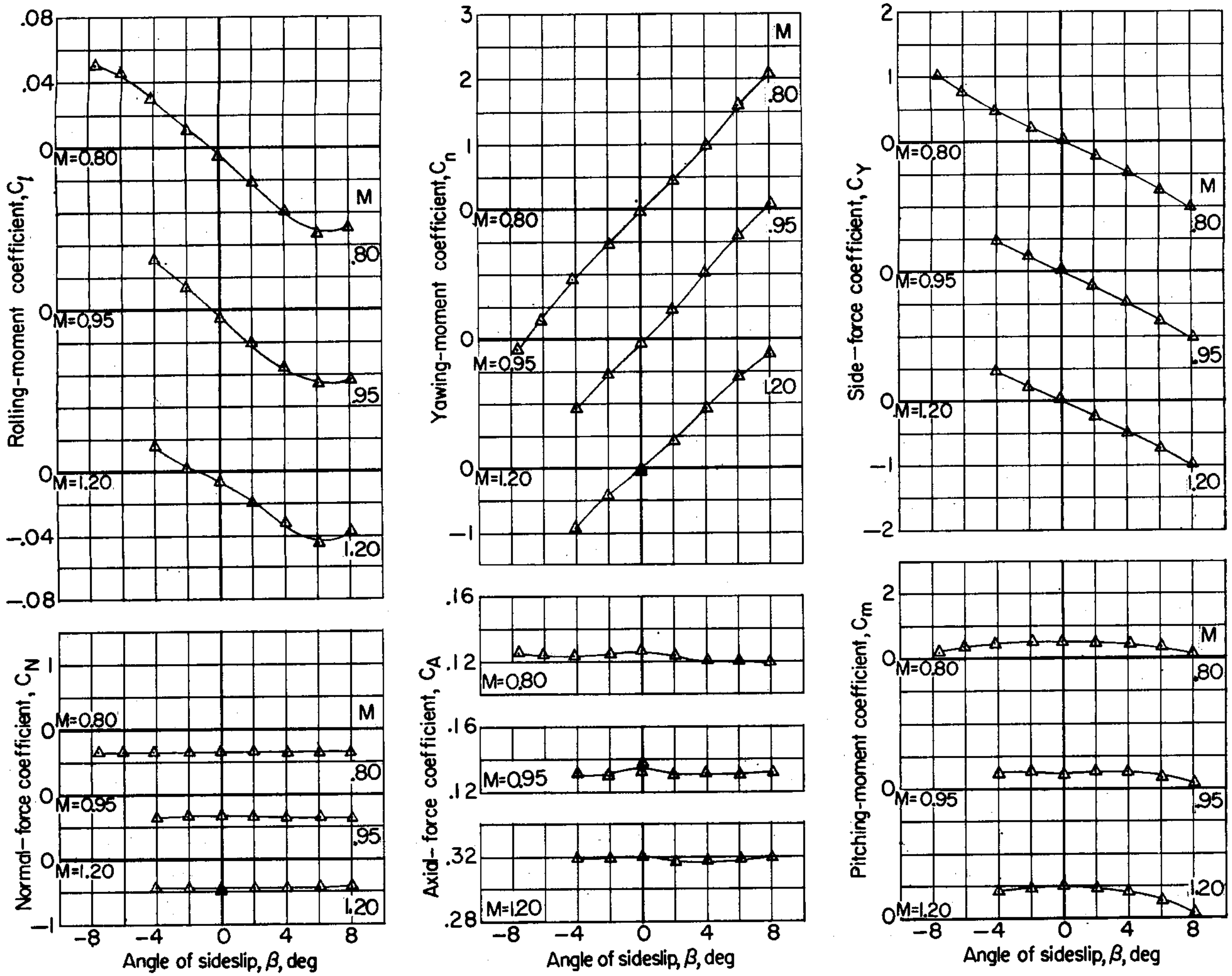

Figure 6.- Variation with angle of sideslip of the aerodynamic characteristics of the body, pylon, and fins $\left(i_t = 0^o\right)$ at various Mach numbers. $\alpha = -5^o$.

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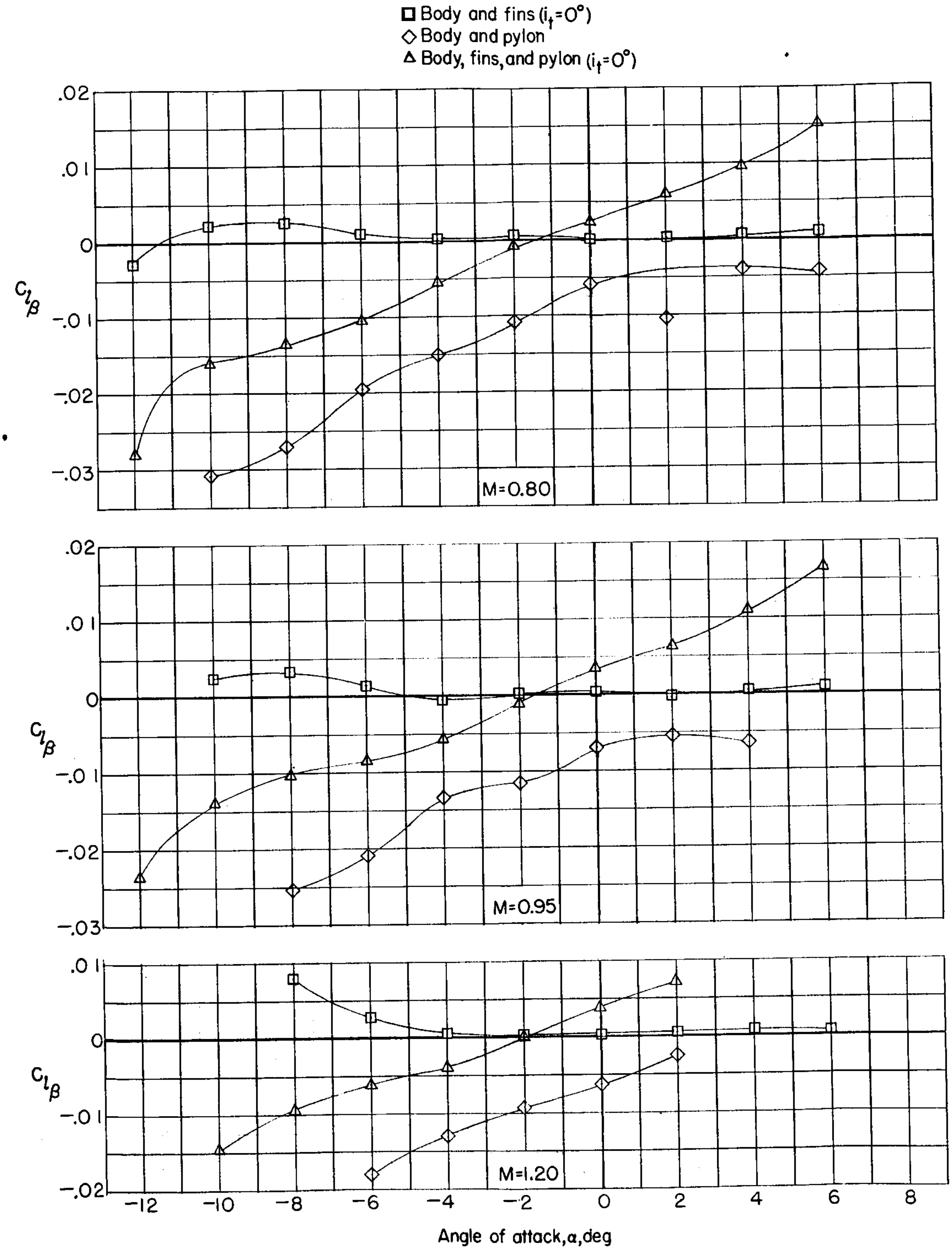

Figure 7.- Variation with angle of attack of the effective dihedral parameter.

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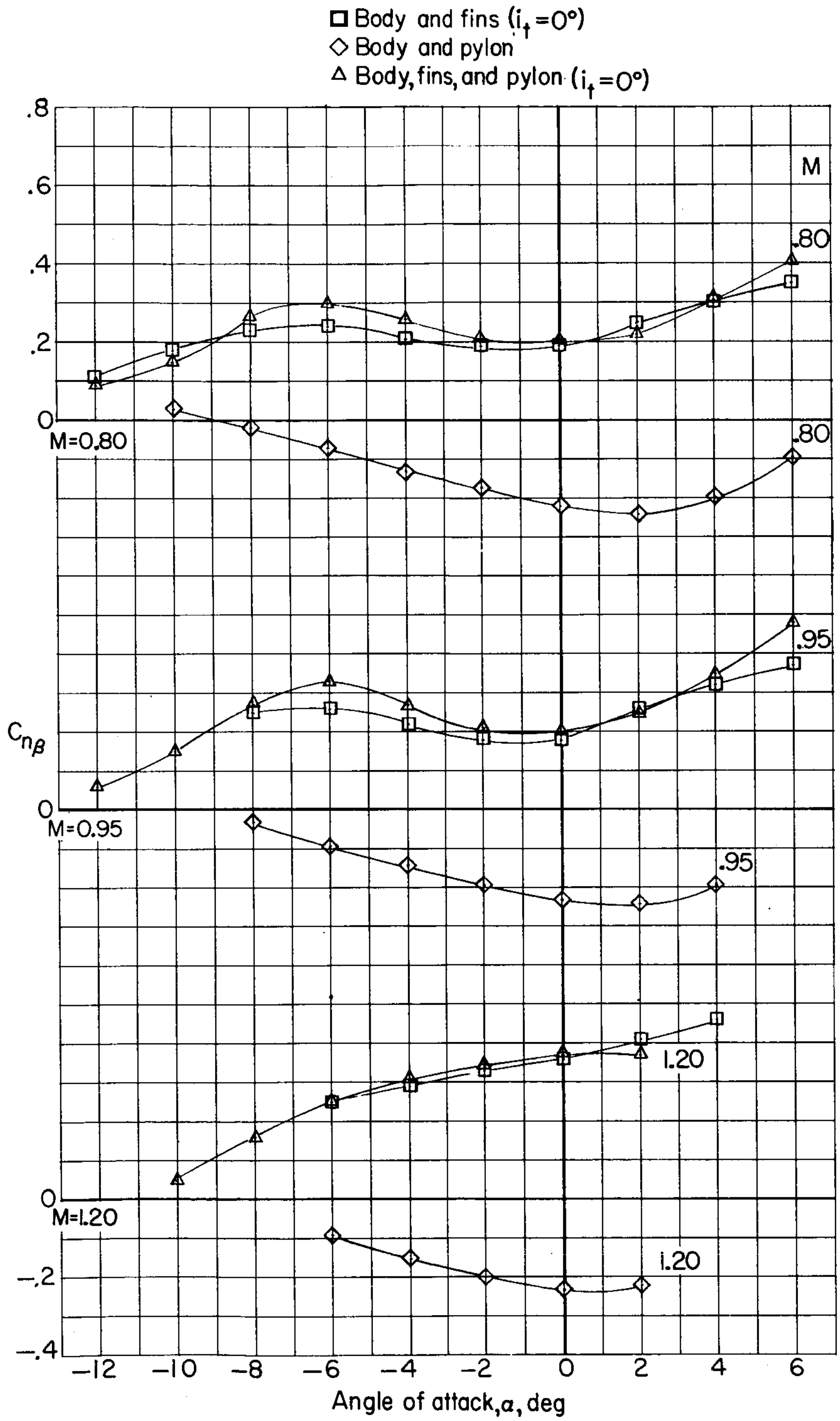

Figure 8.- Variation with angle of attack of the static directional stability derivative.

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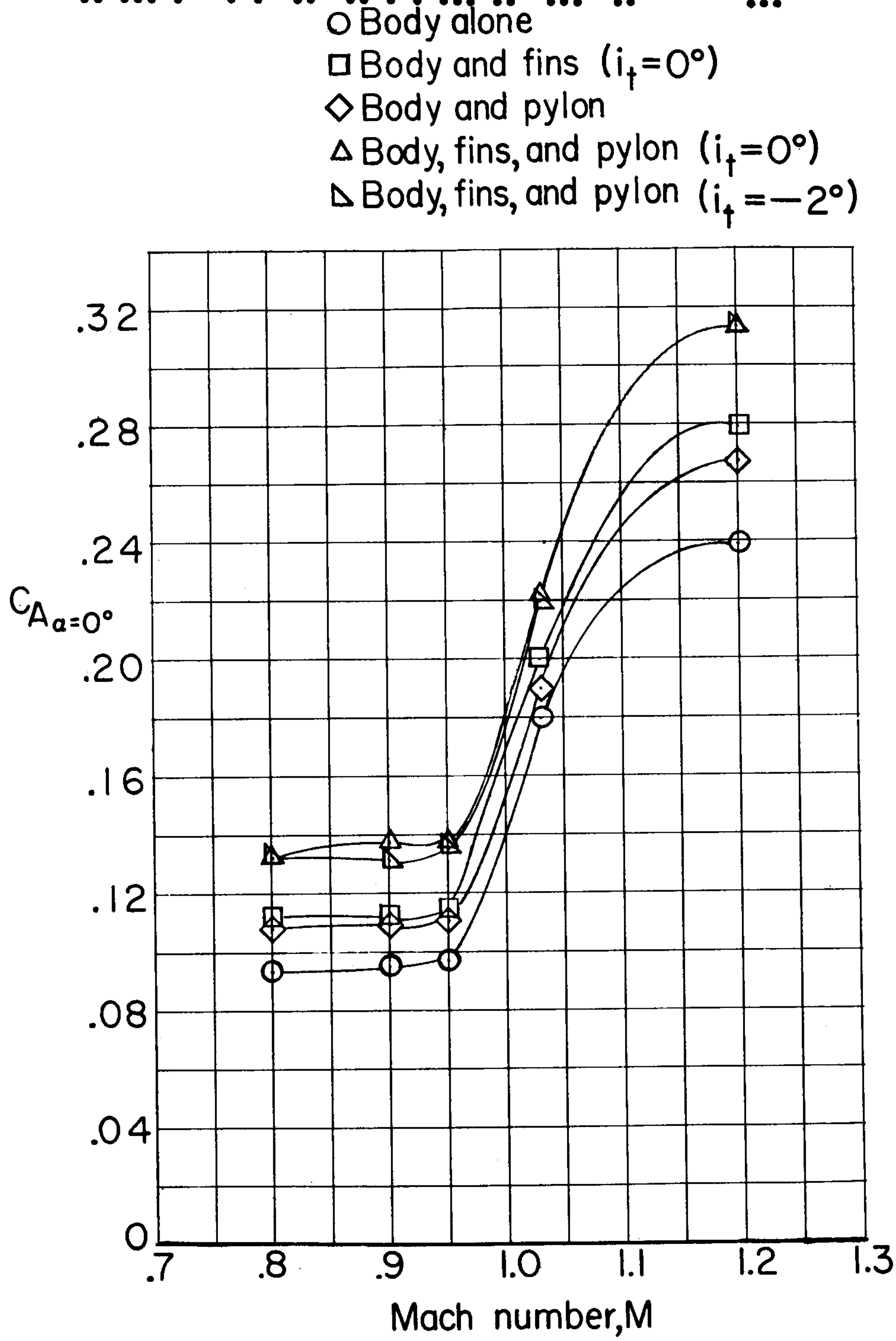

Figure 9.- Variation with Mach number of the axial-force coefficient at zero angle of attack.

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